lier from the firedamp, but enable him to apply it to use, and destroy it at the same time that it gave him a useful light (Phil. Trans. 1816, pp. 23 and 24). Fortunately the ventilation of mines is now better understood than it was in the days of Davy, and the quantities of air employed are usually very much greater. It is certain, however, that in some mines of the present day the ventilation could be doubled or trebled with advantage; and since this is merely a matter of expense it may be asked why it is not done, when it would ensure comparative immunity from danger? On the other hand it is now almost universally admitted to be highly dangerous to continue work in an explosive atmosphere, so that safety-lamps should be used only as a precaution against possible outbursts of gas or when work is carried on in the neighbourhood of gas that cannot be easily dislodged; it is evident, therefore, *primâ facie*, that lamps constructed on the principle of the "safety-lantern," such as the Stephenson, Mueseler, &c., which are extinguished in an explosive mixture, are far safer than lamps like the Davy or Clanny, which continue to burn under the same circumstances, and are then liable, at any instant, to have the flame driven through the wire gauze and communicated to the external explosive atmosphere.

THE COMET

[The following letter appeared in last Thursday's *Times*, from the columns of which journal it is reproduced, with a few verbal alterations.]

I WAS enabled on Sunday night (12th inst.), by Mr. Newall's kindness, to spend several hours in examining the beautiful comet which is now visiting us, by means of his monster telescope—a refractor of 25 in. aperture, which may safely be pronounced the finest telescope in the world, or, at all events, in the Old World.

The view of the comet which I obtained utterly exceeded my expectations, although I confess they were by no means moderate; and as some of the points suggested by the observations are, I think, new, and throw light upon many recorded facts, I beg a small portion of space in the *Times* to refer to them, as it is important that observers should have their attention called to them before the comet leaves us.

I will first deal with the telescopic view of the comet. Perhaps I can give the best idea of the appearance of the bright head in Mr. Newall's telescope, with a low power, by asking the reader to imagine a lady's fan opened out (160°) until each side is almost a prolongation of the other. An object resembling this is the first thing that strikes the eye, and the nucleus, marvellously small and definite, is situated a little to the left of the pin of the fan—not exactly, that is, at the point held in the hand. The nucleus is, of course, brighter than the fan.

Now, if this comet, outside the circular outline of the fan, offered indications of other similar concentric circular outlines, astronomers would have recognised in it a great similarity to Donati's beautiful comet of 1858 with its "concentric envelopes." But it does not do so. The envelopes are there undoubtedly, but, instead of being concentric, they are excentric, and this is the point to which I am anxious to draw attention, and, at the risk of being tedious, I must endeavour to give an idea of the appearance presented by these excentric envelopes. Still referring to the fan, imagine a circle to be struck from the left-hand corner with the right-hand corner as a centre, and make the arc a little longer than the arc of the fan. Do the same with the right-hand corner. Then with a gentle curve connect the end of each arc with a point in the arc of the fan half-way between the centre and the nearest corner. If these complicated operations have been properly performed the reader will have superadded to the fan two ear-like things, one on each side. Such "ears," as we may for convenience call them, are to be observed in the comet, and they at times are but little dimmer than the fan.

At first it looked as if these ears were the parts of the head furthest from the nucleus along the comet's axis, but careful scrutiny revealed, still in advance, a cloudy mass, the outer surface of which was regularly curved, convex side outwards, while the contour of the inner surface exactly fitted the outer outline of the ears and the intervening depression. This mass is at times so faint as to be invisible, but at other times it is brighter than all the other details of the comet which remain to be described, now that I have sketched the groundwork. These details consist of prolongations of all the curves I have referred to backwards into the tail.

Thus, behind the bright nucleus is a region of darkness (a black fan with its pin near the pin of the other pendant from it, and opened out 45° or 60° only will represent this), the left-hand boundary of which is a continuation of the lower curve of the right ear. The right-hand boundary is similarly a continuation of the lower curve of the left ear. Indeed, I may say generally—not to enter into too minute description in this place—that all the boundaries of the several different shells which show themselves, not in the head in front of the fan, but in the root of the tail behind the nucleus, are continuous in this way—the boundary of an interior shell on one side of the axis bends over in the head to form the boundary of an exterior shell on the other side of the axis.

At last, then, I have finished my poor and, I fear, tiresome description of the magnificent and truly wonderful sight presented to me as it was observed, on the whole, during some hours' close scrutiny under exceptional atmospheric conditions.

I next draw attention to the kind of change observed. To speak in the most general terms, any great change in one "ear" was counterbalanced by a change of an opposite character in the other; so that when one ear thinned or elongated, the other widened; when one was dim, the other was bright; when one was more "pricked" than usual, the other at times appeared to lie more along the curve of the fan and to form part of it. Another kind of change was in the fan itself, especially in the regularity of its curved outline and in the manner in which the straight sides of it were obliterated altogether by light, as it were, streaming down into the tail.

The only constant feature in the comet was the exquisitely soft darkness of the region extending for some little distance behind the nucleus. Further behind, where the envelopes of the tail were less marked, the delicate veil which was over even the darkest portion became less delicate, and all the features were merged into a mere luminous haze. Here all structure, if it existed, was non-recognisable, in striking contrast with the region round and immediately behind the fan.

Next it has to be borne in mind that the telescopic object is after all only a section, from which the true figure has to be built up, and it is when this is attempted that the unique character of this comet becomes apparent. There are no jets, there are no concentric envelopes; but, as I have said, in place of the latter, excentric envelopes indicated by the ears and their strange backward curvings, and possibly also by the fan itself.*

I prefer rather to lay the facts before observers than to state the conclusions to be derived from them, but I cannot help remarking that, supposing the comet to be a meteor-whirl, the greatest brilliancy is observable where the whirls cut or appear to cut each other; where we should have the greatest number of particles, of whatever nature they may be, in the line of sight; and not only so,

* By describing three parabolas on a card and spinning the card rapidly round a line not coincident with their common axis, I have been able to reproduce roughly the appearances figured last week and described above.—J. N. L.

but regions of greatest possible number of collisions associated with greatest luminosity.

It would be a comfort if the comet, to partly untie a hard knot for us, would divide itself as Biela's did. Then, I think, the whirl idea would be considerably strengthened. I could not help contemplating the possibility of this when the meaning of the "ears" first forced itself upon my attention.

The spectroscopic observations which I attempted, after the telescopic scrutiny, brought into strong relief the littleness of the planet on which we dwell, for a seven hours' rail journey from London had sufficed to bring me to a latitude in which the twilight at midnight was strong enough to show the middle part of the spectrum of the sky, while to the naked eye the tail of the comet was not so long as I saw it in London a week ago.

I had already in observations in my own observatory, with my 6¼ in. refractor (an instrument smaller than one of Mr. Newall's four finders!) obtained indications that the blue rays were singularly deficient in the continuous spectrum of the nucleus of the comet, and in a communication to NATURE I had suggested that this fact would appear to indicate a low temperature.

This conclusion has been strengthened by Sunday night's observations, and it was the chief point to which I directed my attention. The reasoning on which such a conclusion is based is very simple. If a poker be heated, the hotter it gets the more do the more refrangible—*i.e.* the blue—rays make their appearance if its spectrum be examined. The red colour of a merely red-hot poker and the yellow colour of a candle-flame are due, the former to an entire, the latter to a partial, absence of the blue rays. The colour, both of the nucleus and of the head of the comet, as observed in the telescope, was a distinct orange yellow, and this, of course, lends confirmation to the view expressed above.

The fan also gave a continuous spectrum but little inferior in brilliancy to that of the nucleus itself; while over these, and even the dark space behind the nucleus, were to be seen the spectrum of bands which indicates the presence of a rare vapour of some kind, while the continuous spectrum of the nucleus and fan, less precise in its indications, may be referred either to the presence of denser vapour, or even of solid particles.

I found that the mixture of continuous band spectrum in different parts was very unequal, and further that the continuous spectrum changed its character and position. Over some regions it was limited almost to the region between the less refrangible bands.

It is more than possible, I think, that the cometary spectrum, therefore, is not so simple as it has been supposed to be, and that the evidence in favour of mixed vapours is not to be neglected. This, fortunately, is a question on which I think much light can be thrown by laboratory experiments.

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P.S.—(By Telegraph.)—Wednesday night.—Sunday's observations are confirmed. The cometary nucleus is now throwing off an ear-like fan. Ten minutes' exposure of a photographic plate gave no impression of the comet, while two minutes' gave results for the faintest of seven stars in the Great Bear.

*THE FORMS OF COMETS**

I.

A FEW years ago astronomers studied comets almost solely to determine their movements. So little advance had been made in the study of the figures of these bodies, that M. Arago believed himself justified in stating in his "Astronomie populaire:"—"'I don't know' will still be the reply we have to make to questions asked concerning the tails of comets." If I venture to take as the principal subject of this lecture the researches which I have undertaken during recent years in this difficult subject, I hope to disarm criticism beforehand by at once declaring that the results contrast singularly, by their imperfection, with the degree of power and of certainty we admire in the other more ancient branches of astronomy.

The reason of this contrast is very simple. While planetary astronomy received the precious heritage of the science of the Greeks and the treasury of observations bequeathed by the highest antiquity, cometary astronomy finds in the archives of history observations travestied by superstitious terror. One of the strongest prejudices of previous centuries was that which attributed to the stars a mysterious influence on our destinies. And comets, by their unforeseen appearance in the midst of the familiar constellations, their monstrous heads, their gigantic tails, were calculated to inspire a sort of apprehension which judicial astrology, that long infirmity of the human mind, did not fail to interpret as menacing presages; and as catastrophes have not been wanting in every period of our history, the singular sophism, *post hoc, ergo propter hoc*, so natural to our poor logic, helped to confirm ten or twelve times in a century this miserable superstition.

Did a comet appear in the heavens, morning or evening, the astrologer had to be consulted. He did not go to work without rules; he had a complete classification of strange forms under which these heavenly bodies already had been observed, and to each form was attached a particular signification. Pliny has preserved this nomenclature for us: Hevelius, the learned *pensionnaire* of Louis XIV., faithfully reproduced it in the middle of the 17th century, in the fantastic figures of his *Cometographia*. And, certainly, everything was taken in the most literal manner: in a comet with a crooked, or straight, or multiple tail they traced, such is the power of imagination, a gigantic sabre, a lance, or a fiery bolt, a burning torch or a dragon hurling upon an entire country the plague, rebellion or famine. Figs. 1 and 2 are indications of this idea taken from the "Theatricum cometicum" of Lubienitzki. The first comet, in the form of a blazing torch, indicates very clearly by the direction of its tail the flames which will consume the neighbouring town; the second, a veritable dragon, whose tortuous folds the artist has reproduced, threatens France and Ireland from the seven points of its tongue of fire.

These specimens will suffice; there is no use in producing similar statements and similar pictures; at the most we can barely find here and there in the theories which were then formed some traces of the truth.

Astrology thus stifled real observation until the beginning of the seventeenth century. This may now appear strange to us, but there is no doubt of it. The astronomers of those times, so near in time to ourselves, and already so bold with the universal *renaissance* of the human mind, were almost all to some extent astrologers. Kepler himself, one of the glorious fathers of modern astronomy, was obliged by the duties of his office as Imperial Astronomer both to draw the horoscope of the war of the Pope against Venice, and to give to his powerful but too-straitened patron, the Emperor Rodolph II., an opinion on the comet of 1607, which appeared to be menacing Hungary Besides, Rodolph counted much then upon his alchemist to find the gold necessary to pay his army; while his general, the Duke of Friedland, the celebrated Wallenstein, never failed to consult the heavens, always by the help of Kepler, who has preserved for us his horoscope.

But already, from the time of Tycho Brahé, astronomy had commenced to place a hesitating foot in the domain of comets, from which she was soon to drive astrology. Until then men had lived, upon the faith of

* A lecture by M. Faye delivered at the "Soirées Scientifiques de la Sorbonne." Translated from *La Revue Scientifique*.